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Materiel Test Procedure 6-2-223
Electronic Proving Ground

U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

WEATHER RADAR

1. OBJECTIVE

The objective of this Materiel Test Procedure (MTP) is to describe a procedure for evaluating the technical performance capabilities of weather radars relative to criteria established by Qualitative Materiel Requirements (QMR's), Small Development Requirements (SDR's), or other applicable documents.

2. BACKGROUND

Currently available equipment and techniques for obtaining meteorological data do not provide information with the accuracy, representativeness, reliability, and timeliness necessary to support tactical operations under conditions of mobile, decentralized conventional or nuclear warfare. Weather radar information is essential in the provision of short range forecasts and severe weather warnings, as well as for trafficability and river stage and flood forecasting. Cloud cover data is required for the proper selection of surveillance aircraft and drones under clouds and around and away from areas of severe turbulence. In addition, accurate fallout predictions necessitate information on nuclear clouds.

The development of mobile weather radar systems is essential to the accomplishment of the Integrated Meteorological System (IMS) Concept. To ensure that developmental systems meet applicable military and engineering requirements, the systems must be subjected to adequate engineering tests.

3. REQUIRED EQUIPMENT

a. Radar Resolution Facility
b. Meteorological Support Facility
c. M2 Aiming Circle
d. Oscilloscope
e. Signal Generator
f. Photoelectric Recording Microammeter with associated Photo-Multiplier and ancillary equipments
g. Amplifier
h. Oscilloscope cameras with mounts

NOTE: The facilities and test equipment listed herein represent the minimal required for the performance of tests covered by this MTP. Additional items may be necessary to meet special test requirements.

4. REFERENCES

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H. Radiation Laboratory Series, Vols. 1 - 28, Massachusetts Institute of Technology, 1948.

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J. Department of the Army (DA) Approved Qualitative Materiel Requirement for Mobile Weather Radar, CDOG paragraph 1539c(42), USACDC Action Control Number 5561, 1966.

K. MIL-STD-810B.

L. MIL-STD-461, 462, and 463.

M. MIL-STD-449C.

N. MTP 6-2-519, Frequency Accuracy and Stability.

O. MTP 6-2-222, Radar Target and Ranging.

P. MTP 6-2-020, Radar Antenna Subsystem Tests.

Q. MTP 5-2-520, Ranging System Tests.

5. SCOPE

5.1 SUMMARY

5.1.1 This MTP describes the tests required to determine and evaluate the technical characteristics and performance of weather radar systems. Specific subtests include:

a. Sensitivity Time Control Characteristics - The objective of this subtest is to determine if the test item's sensitivity time control circuits possess the required sensitivity versus time characteristics.

b. Audio Alarm - The objective of this subtest is to determine the received signal strength required to activate the audio alarm.

c. Isoecho Contouring Characteristics - The objective of this subtest is to determine the operational characteristics of the test item's isoecho contouring circuitry.

d. Display Persistence - The objective of this subtest is to obtain a measure of the time required for an oscillographic trace to fade from the display screen and hence to obtain a measure of the averaging or smoothing characteristics of the screen on the intensity modulated signals.

e. Functional Tests - The objective of this subtest is to obtain a

measure of system performance with respect to its intended mission through illumination and observation of targets or opportunity.

f. Spatial Coverage - The objective of this test is to determine the solid angle covered by the radar scan and the time required to complete one scan for the various scanning modes.

g. Radar System Accuracy - The objective of this test is to determine the system accuracy in range, azimuth, and height measurements.

h. Radar Resolution - The objective of this test is to determine under controlled conditions the capability of the system to discriminate between closely positioned targets.

5.1.2 Not included in this MTP are the following common Engineering Tests which apply to this commodity:

a. 6-2-500 Physical Characteristics
b. 6-2-502 Human Factors Engineering
c. 6-2-503 Reliability
d. 6-2-504 Design for Maintainability
e. 6-2-507 Safety

5.2 LIMITATIONS

The methods of extracting climatological data for radarscope film records shall not be discussed in this MTP.

6. PROCEDURES

6.1 PREPARATION FOR TEST

Before any tests are performed on this commodity, the item must have successfully completed MTP 6-2-507, Safety.

6.1.1 Pre-Test Conditions

a. Personnel responsible for conducting the test should ensure that applicable instructions and design specifications are available.

b. Reports of previous Weather Radar tests should be available when appropriate.

c. Operating instructions for test instruments to be used in the conduct of the test should be obtained and available to test personnel.

d. A test log book or folder should be prepared and utilized to record data during tests.

e. Availability of the test tracking range facilities should be checked and firm scheduling verified.

f. Ensure that all test instruments have been calibrated to within desired tolerances.

g. Test personnel should be briefed prior to testing on the purpose of the test and the degree of accuracy expected.

6.1.2 Pre-Test Preparations

a. Test personnel shall review all available instructional material issued with the test item by the manufacturer, contractor or government for familiarity. Refer to Appendix A of this MTP before starting test conduct.

b. Personnel responsible for conducting the tests shall insure that equipment to be tested is in proper operating condition before any measurements are taken. The test item shall be inspected in accordance with appropriate maintenance manuals and noted deficiencies corrected or recorded for consideration during the data reduction phase of the test.

6.2 TEST CONDUCT

6.2.1 Sensitivity Time Control Characteristics

The sensitivity time control characteristics subtest shall be performed in accordance with paragraph 6.2.6 of MTP 6-2-222 with the following exceptions:

a. The sensitivity time control switch shall be in the on position.

b. The sync selector on the signal generator shall be set to the "internal" position with trigger pulse supplied to the STC circuitry and the radar indicator on an oscilloscope external trigger jack.

c. The sensitivity measurement shall be performed at a sufficient number of time delay settings to be able to plot a smooth curve of power input for mid-pulse minimum discernible signal (MPMDS) versus time delay.

6.2.2 Audio Alarm

The audio alarm subtest shall be performed in accordance with paragraph 6.2.6 of MTP 6-2-222 with the following exceptions:

a. All special circuits employed in conjunction with the audio alarm system shall be in the "on" position and the signal generator trigger pulse shall be applied as applicable.

b. The signal generator output power shall be brought from mid-pulse minimum discernible signal, (MPMDS), to the minimum signal level required to sustain the audio alarm.

c. Obtain a sufficient number of data points to allow the plotting of a smooth curve of power input to activate the audio alarm versus time delay.

6.2.3 Isoecho Contouring

The Isoecho Contouring subtest shall be performed in accordance with paragraph 6.2.6 of MTP 6-2-222 with the following exceptions:

a. Isoecho contouring and related functional switches shall be in the on position.

b. Perform the sensitivity measurement as indicated in paragraph 6.2.1, then increase signal generator amplitude until the PPI display becomes black, indicating the blanking threshold has been reached.

c. Compute the power gradient from the difference of the two signal generator attenuator settings.

d. Repeat measurements under varying conditions of delay time and contouring level as applicable.

NOTE 1: The isoecho-contour circuitry is used because the limited dynamic range of intensity modulated PPI displays permit little contrast in targets of different magnitudes. Sensitivity time control (STC) must be used with isoecho contour displays since this technique depends on differences in signal amplitudes. STC attempts to ensure that any measured differences in echo amplitude are due to differences in rainfall rate and not differences in range.

NOTE 2: The above subtest shall be performed at a sufficient number of level settings to allow plotting a smooth curve of power gradient versus level setting.

6.2.4 Display Persistence

a. Arrange equipment as shown in figure 1.

b. Energize equipment and adjust signal generator pulse characteristics to duplicate those generated by the test item.

NOTE: Input power level shall be a convenient value between system sensitivity and limiting.

c. Adjust the system gain to maximum and the display intensity to the maximum permissable level without image "blooming" or excessive noise excitation.

NOTE: Test item time constant controls shall be set as appropriate to recover the incoming pulse envelope.

d. Adjust the signal generator pulse repetition frequency such that the indicated luminance level is allowed sufficient time for complete decay between pulses. Photograph at least one cycle of the luminance decay curve and detected pulse envelope on the calibrated oscilloscope.

e. Increase the signal generator pulse repetition frequency until the observed luminance decay curve is limited to 90% of the complete decay as recorded in d above. Record the pulse repetition frequency and again photograph the oscilloscope display.

f. Repeat the above procedure for varying degrees of display intensity and as necessary to determine the effects of any special circuitry such as memory span or mesh storage.

6.2.5 Spatial Coverage

a. Place equipment over point and turn survey angles from this point using an M2 Aiming Circle.

b. With test item oriented on one mark rotate equipment through an

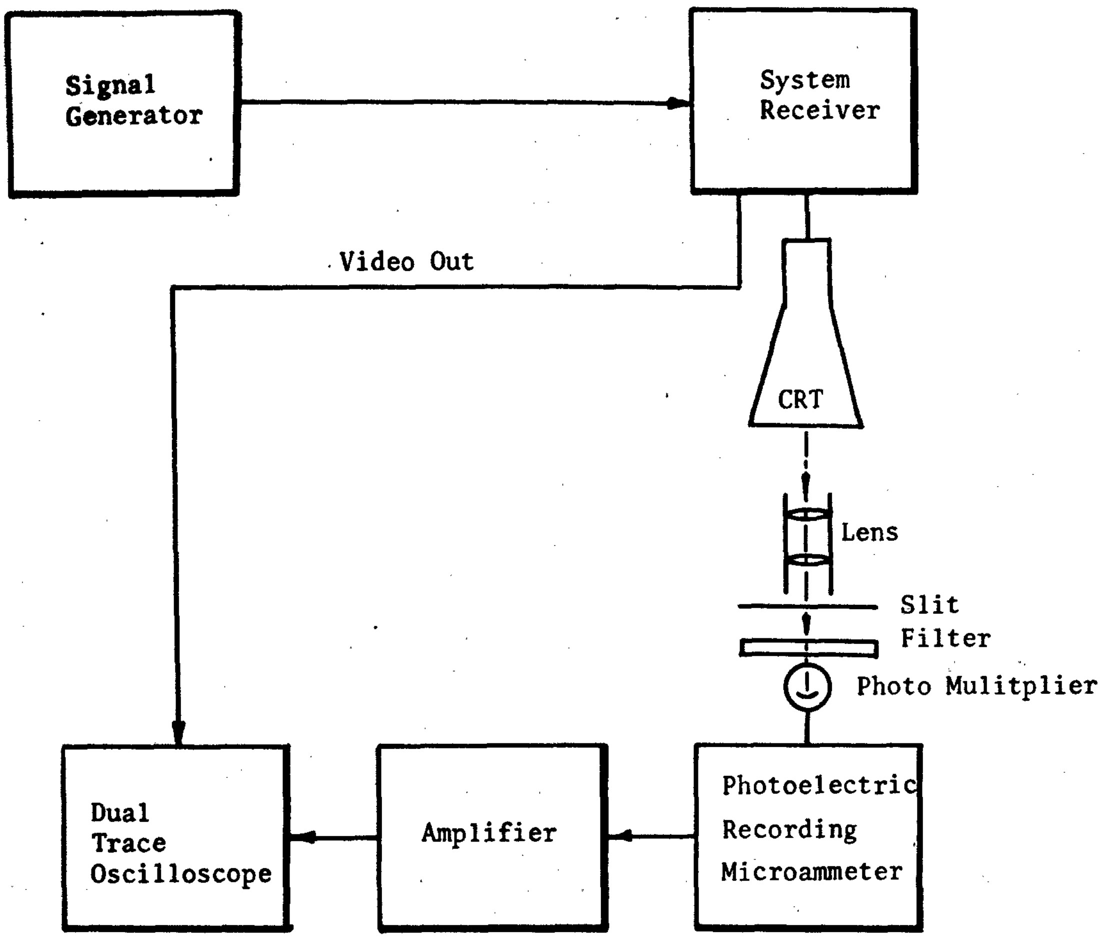

Figure 1. Display Persistence Measurement Block Diagram

arc determined by sector scan controls. Record the following:

1) Indicated scan angle
2) Measured scan angle
3) Elapsed time of each scan

c. Repeat step b a sufficient number of repetitions to determine if inaccuracies occur due to overshoot or other mechanical problems.
d. Repeat procedure for elevation scan characteristics.

6.2.6 Radar System Accuracy

The test item will be set up and oriented at successive vantage points. Target locations will then be determined by each of three operators. Test item-target separation distances shall include the minimum specified radar range and the maximum range of the facility. A Radar Resolution Facility, if available, should be used for this test.

a. Perform first order survey (if required) to determine target azimuth, elevation, and range for each vantage point-target combination.
b. Turn equipment on and direct energy on first target. Determine and record the indicated azimuth, elevation and range measured by the test item. Repeat measurement using two other operators.
c. Repeat step b for other vantage point-target combinations.

6.2.7 Radar Resolution

The radar resolution shall be accomplished using a Radar Resolution Facility - if available. Corner reflector type targets will be selected to provide a reflected signal whose amplitude will be above the background clutter, but not so great as to cause saturation of the radar receiver.

a. Position test item on a vantage point which represents the maximum radar range from the center of the target complex.
b. Position targets to allow a range separation of 100 meters.
c. Increase or decrease, depending on results of first test, to determine the extent of range resolution. Each of three operators will make separate determinations of range resolution.
d. Repeat steps b and c with targets separated azimuthally under changing conditions of target spacing to determine actual azimuth resolution at maximum range.
e. Repeat above procedures at various ranges including minimum specified radar range.

6.2.8 Functional Tests

a. Utilizing meso meteorological forecasts of expected conditions, the test item shall be stationed so as to acquire the anticipated conditions when they materialize.
b. Upon materialization of expected meteorological phenomena, the

test system shall be energized to obtain essential data according to standing operating procedures for data acquisition.

c. Radar displays shall be photographed and photographs time correlated to the independently recorded meteorological data.

> **NOTE:** Stationing of the test item should also consider the availability of known reflectors such as radar range targets, buildings, or hills so that a measure of atmospheric attenuation may be obtained by observation of the loss in signal return from the known target as the target of opportunity crosses the signal path. Additional consideration should be given to the system reaction to simulated nuclear detonation through the use of buried, conventional explosives. In this case, the target phenomena is less fortuitous in nature and will allow for more precise instrumentation including measurement of cloud growth rate, particle size, etc. A field test of the audio alarm system would also be possible at this time.

6.3 TEST DATA

In addition to specific test data listed in subsequent paragraphs, a block diagram of the test setup employed in each specific test shall be prepared. The block diagram shall identify by mode and serial number, all test equipment and interconnections (cable lengths, connectors, attenuators, etc.) and indicate control and dial settings where relevant.

6.3.1 Sensitivity Time Control Characteristics

Sensitivity time control characteristics test data shall be recorded in the following general format, if obtainable.

Radar Nomenclature____________________Receiver Serial No.______________

Pulse Width____________(μs) Pulse Repetition Rate________________(pps)

Tuned Frequency________________(MHz)

Time Delay (μsec)	Coupling Factor (db)	Other Losses (db)	Power Input for MPMDS (dbm)

6.3.2 Audio Alarm

Audio alarm test data shall be recorded in the following general format, if obtainable.

Radar Nomenclature ________________ Receiver Serial ____________

Pulse Width ____________ (μs) Pulse Repetition Rate ______________ (pps)

Tuned Frequency __________ (MHz)

Time Delay (μs)	Coupling Factor (db)	Other Losses (db)	Power Input to activate alarm (dbm)

6.3.3 Isoecho Contouring

Isoecho contouring test data shall be recorded in the following general format:

Radar Nomenclature ________________ Receiver Serial No. __________

Pulse Width __________ (μs) Pulse Repetition Rate ________________ (pps)

Tuned Frequency __________ (MHz)

Isoecho Control	Time Delay (μs)	Power Input for MPMDS (dbm)	Power Input for blanking (dbm)

6.3.4 Display Persistence

a. Record and preserve the calibrated photographs of the oscilloscope display and the microammeter output.
b. Record the pulse repetition frequency at which the luminance decay curve is limited to 90% of complete decay.
c. Record the brightness of the background noise.
d. Record the ambient brightness level.
e. Record the brightness of the signal spot above the background noise level.

6.3.5 Spatial Coverage

For both azimuth and elevation scan characteristics

a. Record indicated sector scan from test item
b. Record actual sector scan from measured angle.
c. Record elapsed time for each scan

6.3.6 Radar System Accuracy

a. Record radar azimuth, elevation, and range readings to each target for each operator.
b. Record surveyed azimuth, elevation, and range readings for each

target.

6.3.7 Radar Resolution

Record measured radar resolution in meters for each range and target types.

6.3.8 Functional Tests

Data to be recorded for the functional test shall be the radarscope film records together with the maximum obtainable information concerning the illuminated target. Meteorological Support Activity weather records will be included.

6.4 DATA REDUCTION AND PRESENTATION

All test data shall be properly marked for identification and correlation and grouped according to subtest title. Test criteria or test item specifications shall be noted on the test data presentation to facilitate analysis and comparison. Where necessary, test data measurement units shall be converted to be compatible with units given by test criteria or specifications.

6.4.1 Sensitivity Time Control Characteristics

a. Sensitivity time control data shall be presented in the general tabular form indicated in paragraph 6.3.1. Graphical presentations of these data shall be constructed displaying values of power input for mid-pulse minimum discernable signal as a function of time delay or equivalent radar range.

b. Compare results of testing as obtained and presented in a above, with prescribed rules and determine whether acceptable.

6.4.2 Audio Alarm

a. Audio alarm data shall be presented in the general tabular form indicated in paragraph 6.3.2. Graphical presentations of these data shall be constructed displaying values of power input to activate the audio alarm versus time delay or equivalent radar range.

6.4.3 Isoecho Contouring

a. Isoecho contouring data shall be presented in the graphical tabular form indicated in paragraph 6.3.3. Graphical presentations of these data shall be constructed displaying values of power difference versus time delay or equivalent radar range, where the power difference is computed from the relationship:

Power Difference (db) = Power input for blanking (dbm) - power input for MPMDS (dbm).

b. Same as 6.4.1,b.

6.4.4 Display Persistence

a. Present data recorded in 6.3.4 in terms of the following:

1) PRF at which luminance decay curve is limited to 90% of complete decay.
2) Photographs of the oscilloscope display and microammeter output.
3) Brightness of background noise.
4) Contrast as computed below:

a) $$\text{Contrast} = \frac{B}{B_n + B_a}$$

where: B_n = Brightness of background noise
B_a = Mean ambient brightness level
B = Brightness of signal spot above background noise level.

b. Same as 6.4.1,b.

6.4.5 Spatial Coverage

Prepare a table showing the following parameters:

a. Scanning mode control setting
b. Measured azimuth scan angle and elapsed time of scan
c. Measured elevation scan angle and elapsed time of scan

6.4.6 Radar System Accuracy

Prepare table of indicated and actual values of target azimuth, elevation and range.

6.4.7 Radar Resolution

Prepare graph of target separation versus range for various targets.

6.4.8 Functional Test

a. Reduction and presentation of the functional test data will depend to a large degree on the nature and extent of the compiled information. A sample presentation, based on a composite radarscope film record and conventional surface weather analysis is shown in Figure 2.

b. In essence, the reduction and presentation of the functional test data shall present the maximum obtainable information, in the most concise form so as to permit a determination to be made if the test item is capable of detecting, locating and measuring to the degree of accuracy, those meteorological phenomena specified in the appropriate QMR, SDR, TC or other system specification.

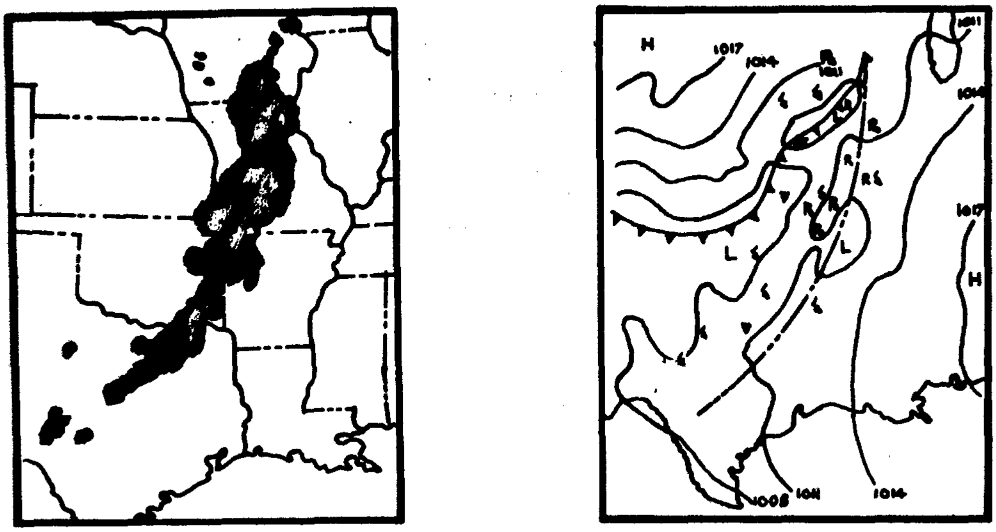

Figure 2. Composite radar picture showing a large scale squall line. The various radar photographs used in the composite picture were retouched and all non-weather echoes removed. A surface weather map for the same time as the radar data is shown on the right.

APPENDIX A

Audio Alarm

Developmental weather radar systems may include an alarm feature which produces an audible signal when a nuclear target return above a predetermined strength occurs. In this automatic capability, the scope trace out to 10 miles in range may be "blanked-out" to keep nearby target returns from affecting the desired operation.

Isoecho Contouring

The isoecho-contour circuit is used because the limited dynamic range of intensity modulated PPI displays permits little contrast in targets of different magnitudes. Sensitivity time control (STC) must be used with the isoecho-contour display since the isoecho-contour technique depends on differences in signal amplitude. STC attempts to ensure that any measured differences in echo amplitude are due to differences in rainfall rate and not to differences in range.

Functional Tests

A. If properly exploited, the photographic recording of radar cathode ray tube displays, while the system is illuminating known meteorological phenomena, can yield valuable data concerning the system design and operation. Although difficult or impossible to achieve at times, independent instrumental observation of the phenomena is required for an engineering test as it will allow for data analysis with respect to another measurement and hence produce a more detailed and objective test.

B. In general, a knowledge of the following parameters relating to the gross state of the meteorological target would suffice:

1. Location, Orientation, size and shape.
2. Direction and speed of movement.
3. Intensity
4. Character (general qualitative assessment, including fluctuaation rate). Where feasible, however, more detailed data concerning the above parameters and other items of interest (e.g. refractive index, attenuation, fall velocity) should be collected and preserved for analysis.

Modification Of Radar Range Equation for Weather Problem

A. As indicated in Appendix A of MTP 6-2-222, the selection of major radar system test parameters can be directly related to the radar range equation. Of prime importance in the radar range equation as applied to weather radar systems is the variable σ. The variable σ, as defined in MTP 6-2-222, is the contribution made by the target, in this case a meteorological disturbance which takes on special significance for two reasons. First, the radiated energy may have to pass through accumulations of hydrometeors, suffering attentuation during its round trip. Secondly, the target itself possesses appreciable cross-sectional

area and depth; storms are never classed as point targets. Assuming that the area of a meteorological target exceeds that of the intersected radar beam (a beam-filling target) and the target depth exceeds half the distance occupied by the pulse as it propagates through space, σ may be expressed in terms of:

$$\sigma = \frac{R^2 \phi\theta \ \tau c n}{2} = n \times \text{volume occupied by radiated pulse at range } R$$

where $R^2\phi\theta$ = illuminated area at range R for an antenna of half-power beam widths ϕ and θ

τ = pulse length
c = velocity of propagation
n = scattering cross section per unit volume of target

B. The variable n (scattering coefficient) is in turn, a rapidly changing function of the size, shape, phase and orientation of the hydrometeors in the atmosphere and, in essence, is responsible for the character of the radar display.

C. In conclusion, the test and evaluation of a radar weather system requires an interdisciplinary effort involving expertise in both radar systems and meteorology.